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# THINNING PONDEROSA PINE TO PREVENT OUTBREAKS OF MOUNTAIN PINE BEETLE

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*ABSTRACT*

*Severe tree killing by Dendroctonus ponderosae is an increasing pest problem in second-growth Pinus ponderosa stands in Oregon and Washington. Particularly affected are even-aged pole stands 60 to 80 years old on poor sites. Excessive between-tree competition generally underlies the occurrence of beetle outbreaks, as infested trees typically have grown less than 1 inch in diameter during the decade prior to attack and have live crowns shorter than one-third of stem height. Severity of beetle-caused mortality is related to stand density, which indicates that thinning of dense stands will prevent beetle outbreaks.*

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## INTRODUCTION

In the past, virgin ponderosa pine forests in the Pacific Northwest seldom suffered outbreaks of mountain pine beetle, Dendroctonus ponderosae (=D. monticolae) (Craighead et al. 1931). However, severe tree killing has become increasingly widespread with logging of the old-growth stands and subsequent expansion of second-growth acreage. Outbreaks occurred on about 100,000 acres annually during the recent 10 years, and because these were predominately concentrated in stands developing on the oldest cutover areas, this pest problem seems destined to become more extensive as additional young stands attain susceptible age and size. Accordingly, the Northwest Forest Pest Action Council has recognized mountain pine beetle as a major obstacle to orderly conversion from an old-growth to a second-growth economy.

## THE BEETLE

This insect was considered to be two species until these were combined recently by Wood (1963). In the Rocky Mountain region, there was D. ponderosae, with the common name, Black Hills beetle. In the Pacific Coast states, D. monticolae was known commonly as mountain pine beetle. The scientific name, D. ponderosae, and the common name, montain pine beetle, designate the presently recognized single species.

Mountain pine beetle is similar in appearance to several other bark beetles and thus is difficult to identify without a microscope. However, identification of trees killed by it is easy, for its tunnel pattern in the inner bark is distinctive among the beetles commonly attacking ponderosa pine in the Pacific Northwest. Tunnels made by egg-laying females are fairly straight and about 2 feet long (Figure 1); whereas, those of other species are either much more winding or considerably shorter.

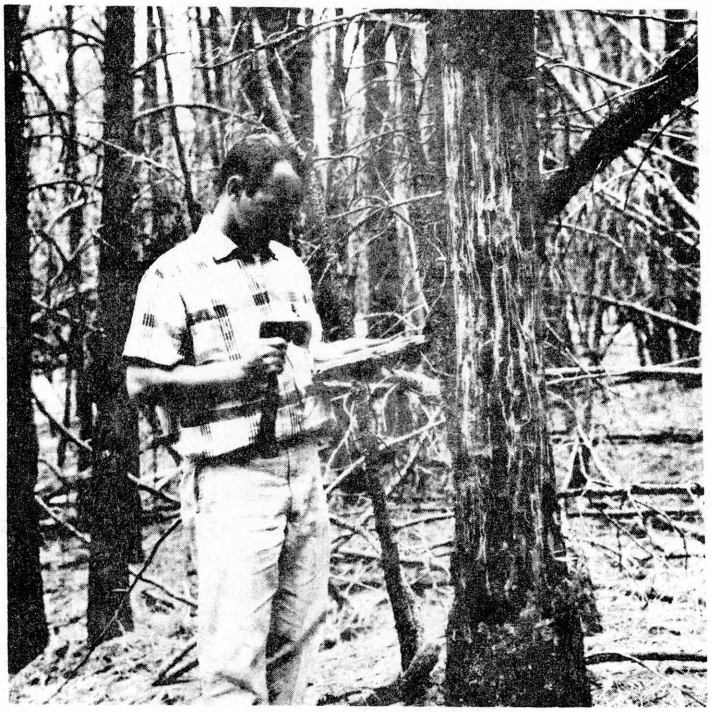

Figure 1. Entomologist examining ponderosa pine killed by mountain pine beetle.

## OCCURRENCE OF OUTBREAKS

The increase in outbreaks of mountain pine beetle in ponderosa pine began in this region about 25 years ago when the oldest second-growth stands reached the late pole stage or approximately age 60 years. This more or less corresponds to the time when, according to normal stand projections of Meyer (1961), fully stocked stands ordinarily first attain "maximum" stand density in terms of stem basal area.

Initial infestations in the life of an even-aged stand seem to occur earlier on good sites than on poor ones--sometimes about age 50 in site class III stands, but often not until beyond age 80 in site VI stands. For this region generally, however, where most ponderosa pine occurs on site IV and V lands, stands usually sustain their first serious beetle infestations between ages 60 to 80 years.

Outbreaks of mountain pine beetle in ponderosa pine rarely develop suddenly; rather they build up over several years. Endemic infestations typically involve less than five trees per acre per year and generally occur in widely scattered single trees or in groups of two or three trees. In the first year of an outbreak, about five to ten trees per acre are killed and group kills of three to five trees are common. Subsequently, the number of infested trees increases to a peak level of about 30 to 150 trees per acre per year in the third to fifth years and then declines. Within a stand, the duration of an outbreak from onset through collapse is generally about 6 to 8 years and tends to be shorter on good sites and longer on poor sites.

Other infestations occur in later stand development. Although these become progressively less severe with time, they continue the natural conversion of even-aged stands into all-aged ones where ponderosa pine forms nearly pure climax stands (Keen 1950). Where the pine is a minor element in the climax type, beetle-caused tree killing hastens ecological succession toward a more diversified species composition (Eaton 1941).

## CHARACTERISTICS OF KILLED TREES

### Diameter

Figure 2 shows mortality by diameter during a 10-year period for three pole stands, each representing one of the common ponderosa pine site classes in the Pacific Northwest. All three stands apparently attained full stocking early in their development and subsequently were not significantly influenced by fire.

The effect of site quality upon the character of tree killing was quite marked. In the site class III stand, beetle-caused tree mortality constituted a natural thinning from below. In the site IV stand, tree killing essentially was indiscriminate, as similar portions of most diameter classes were killed. In the site V stand, beetle-caused killing tended to be a thinning from above. Also, the general level of mortality was higher on poor sites than on good ones.

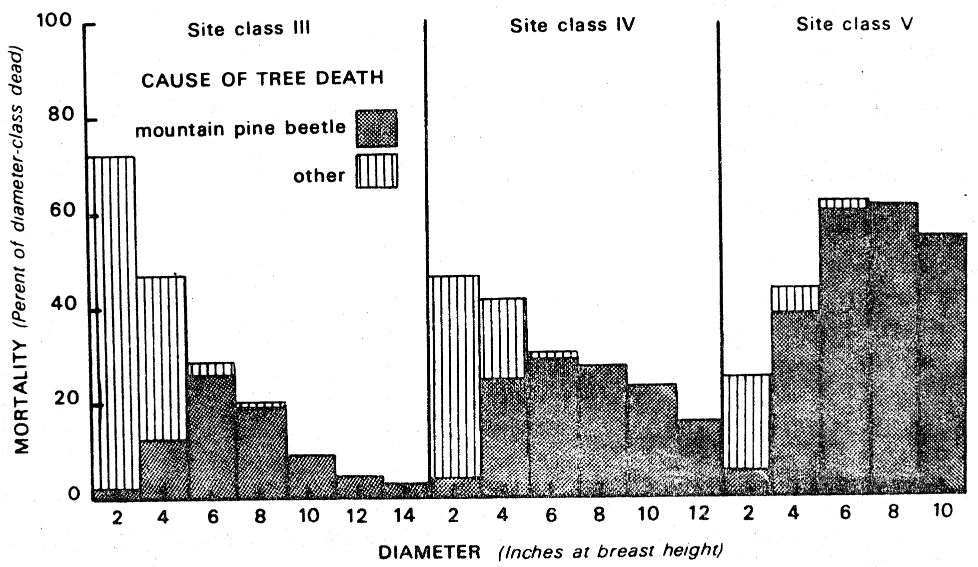


Figure 2. Tree mortality by diameter and cause during 10 years of pole stage for three typical pure, even-aged ponderosa pine stands.

These findings reveal the general nature of beetle impact. On good sites, the beetle is a pest of minor consequence, except where commercial harvest of suppressed and intermediate trees is planned. On intermediate sites, planned rotations may have to be lengthened to compensate for the killing of numerous large trees. On poor sites, outbreaks will usually require major revision of management plans, as entry of a new age class will be necessary to restock the large stand openings created by beetle-caused mortality.

Recent Radial Growth

Blackman (1931) found that trees killed during outbreaks generally had been growing more rapidly than surviving pines. However, such a comparison obscures the fact that slow growth is characteristic of nearly all beetle-killed trees. I have examined 666 infested trees and found that only three had grown more than 1 inch in diameter during the 10 years prior to beetle attack (Table 1). Generally, these trees had been growing about one-third to one-half the rates considered normal by Briegleb (1943), an indication they were suffering from severe between-tree competition.

Live Crown Ratio

Percentage of the stem bearing live branches is one of the best measures of crowding in forest stands (Czarnowski 1961). According to Smith (1962), trees become much reduced in vigor when the live crown ratio decreases to 30%, and Dahms (1954) and Barrett (1968) recommend that artificial pruning should never reduce the live crown of ponderosa pines to less than one-third of tree height.

Table 1. Recent radial growth of ponderosa pines killed by mountain pine beetle.

| Crown class | Years to grow last inch of diameter | | | Total trees |
|---|---|---|---|---|
| | 1-10 | 11-20 | 21+ | |
| | Number of trees | | | |
| Dominant | 2 | 53 | 13 | 68 |
| Codominant | 1 | 112 | 117 | 230 |
| Intermediate | -- | 55 | 241 | 296 |
| Suppressed | -- | 8 | 64 | 72 |
| Total | 3 | 228 | 435 | 666 |

I have ocularly estimated the live crown ratios of 3,989 trees killed by mountain pine beetle and found that nearly 91% had ratios of 30% or less (Table 2). Judged by the crown-vigor classification of Keen (1943), beetle-killed dominants and codominants generally had shorter and thinner crowns than is typical of upper canopy trees. This is another indication that excessive between-tree competition underlies the killing of ponderosa pine by mountain pine beetle.

Table 2. Live crown ratios[1/] of ponderosa pines killed by mountain pine beetle.

| Crown class | Live crown ratio | | | | | | Total trees |
|---|---|---|---|---|---|---|---|
| | 60 | 50 | 40 | 30 | 20 | 10 | |
| | Number of trees | | | | | | |
| Dominant | 1 | 33 | 104 | 112 | 8 | -- | 258 |
| Codominant | -- | 34 | 167 | 395 | 168 | 3 | 767 |
| Intermediate | -- | -- | 30 | 420 | 960 | 365 | 1,775 |
| Suppressed | -- | -- | -- | 124 | 542 | 523 | 1,189 |
| Total | 1 | 67 | 301 | 1,051 | 1,678 | 891 | 3,989 |
| | Percentage distribution | | | | | | |
| Total | <.1 | 1.7 | 7.6 | 26.3 | 42.1 | 22.3 | 100.0 |

[1/] Percentage of stem length bearing live branches at time of death.

## TREE KILLING IN RELATION TO STAND DENSITY

The association of mountain pine beetle outbreaks with high stand densities of ponderosa pine has long been apparent (Eaton 1941, Keen 1950, Clements 1953, Sartwell 1969) but not quantified until recently.[1] I measured beetle-caused mortality in eight localities and found a significant and direct relation to stand density (stem basal area) in all localities (Figure 3). I also found this relationship was stronger on poor sites than good sites.

The relation of beetle-caused mortality to stand density is believed to occur because overcrowding reduces the vigor of ponderosa pines and allows the beetle to overcome a larger proportion of the trees in a dense stand than in a sparse one. The difference in this relationship between sites may arise because trees regain vigor earlier on good sites than on poor ones following the death of competing neighbors.

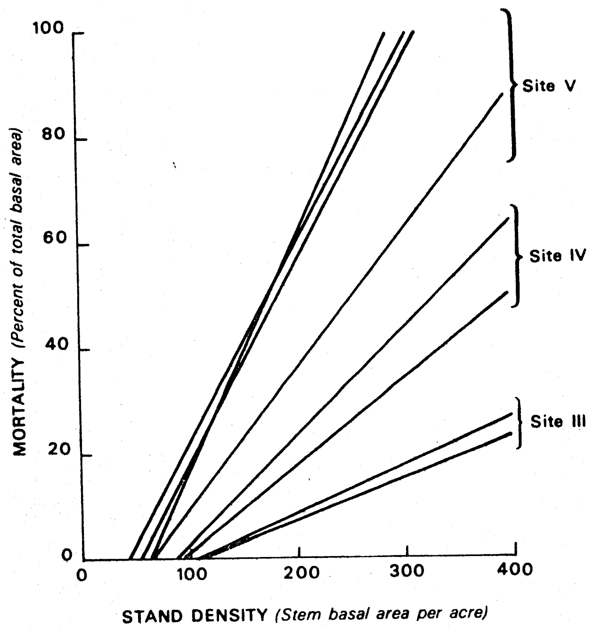


Figure 3. Relation of tree killing by mountain pine beetle to stand density in eight pole stands of ponderosa pine.

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[1] Charles Sartwell. Killing of ponderosa pine by mountain pine beetle in relation to stand density. (Manuscript in preparation)

## THINNING TO PREVENT OUTBREAKS

The evidence presented here indicates that thinning to minimize between-tree competition is the probable key to long-term prevention of mountain pine beetle outbreaks in ponderosa pine. This idea first occurred to Eaton (1941). He set up a crop-tree thinning experiment in 1938, but his plots were destroyed by fire a few years later.

Two small-scale tests of thinning to prevent outbreaks were subsequently installed by other investigators during 1960-61. Both tests involved only one thinning level and were installed in areas where outbreaks had recently begun. The thinned plot in one test area now has about five times as many stems as the surrounding unthinned stand, which has been decimated by mountain pine beetle during the intervening years.[2/] The beetle population in the vicinity of the second test was suppressed by insecticidal treatment before the thinning was made. The outbreak resumed about 5 years later in the unthinned stand, but the thinned plots have not yet been significantly affected by the beetle.

A larger test of thinning for outbreak prevention was installed in 1967 on about 200 acres in a site V, 55-year-old stand near Baker, Oregon. Spacings of about 12, 15, 18, and 21 feet are being compared against no thinning. This range of thinnings was applied to find out if wide spacings prevent outbreaks for a longer period than do close spacings. Protection from severe killing by mountain pine beetle for about 10 to 30 years, perhaps longer, is hypothesized from projections of normal stand growth by Meyer (1961). Replication of this test in other areas is now being planned.

Insufficient time has passed for these experiments to yield a solid base for specific pest management recommendations. However, because a large acreage of second-growth pine stands apparently will sustain outbreaks before test results become available, it seems desirable to offer a "best guess" that will allow forest managers to deal with the pest problem during the interim. The following recommendation is based upon (a) the assumption that Meyer (1961) has fairly well defined the stand density levels at which ponderosa pine populations are naturally regulated, and (b) the tentative conclusion that outbreaks of mountain pine beetle are generally spectacular cases of natural stand density regulation in operation (Sartwell 1969). I speculate that severe tree killing can be prevented for 25 to 30 years by thinning to reduce stand densities below:

| Site class | Stem basal area per acre |
|---|---|
| III | 160 square feet |
| IV | 140 square feet |
| V | 120 square feet |

[2/] Ralph C. Hall and Glenn R. Davies. Mountain pine beetle epidemic at Joseph Creek Basin, Modoc National Forest. Unpublished report filed at Division of Timber Management, California Regional Office, U.S. Forest Service, San Francisco. November 1968.

These suggested residual densities are higher than recommended in Forest Service silvicultural guidelines. These suggestions are merely for preserving the even-aged quality of second-growth stands; whereas, the main purpose of ordinary precommercial thinnings is maximizing growth of crop trees, which requires heavier thinnings.

## DISCUSSION

Thirty years ago it was frequently predicted that bark beetle problems in the ponderosa pine forests of eastern Oregon and Washington would decrease greatly once the virgin timber was harvested. Indeed, the importance of western pine beetle, D. brevicomis, has been diminished now that about three-fourths of the old-growth acreage has been logged. But in its stead the mountain pine beetle has risen from comparative obscurity as a pest in virgin forests to prominence as a tree killer in second-growth stands.

Why was the prediction wrong? First, it did not include recognition that second-growth stands, with their simple age structure, are less ecologically stable than were the all-aged virgin forests. Even-aged stands were uncommon in the past (Weidman 1921); they now cover about 2 million acres in the Pacific Northwest. Second, the great ecological change brought on by the intentional exclusion of fire was not taken into account. The elimination of this agent as a common influence in the dynamics of second-growth stands has allowed them to attain high stand densities much more often than did their virgin predecessors (Weaver 1943).

Dense, even-aged stands on a large acreage: This is the situation in which severe infestations of mountain pine beetle are becoming increasingly common in the ponderosa pine forests of the northwestern United States. According to Graham (1956), some insect outbreaks are spectacular applications of the "law of natural compensations." Graham contended that this law operates in all tree populations but is enforced most conspicuously in unstable forests. A characteristic of insects enforcing this law is that they seldom become outbreak in climax forests but frequently do where stand stability has been disrupted by nature or man. Available historical evidence and the findings presented here indicate that mountain pine beetle plays a compensating role in the ponderosa pine ecosystems of this region. Hence, its recent outbreaks can be viewed as natural consequences of human influences upon pine ecology.

What does applicability of the law of natural compensations to this pest problem mean to forest managers? First, it indicates that the killing of beetles, such as by spraying infested trees with an insecticide, generally will provide only temporary relief from damage, as the beetle population will tend to build up rapidly again as long as stand conditions are not improved. Second, it indicates that beetle impact over the long run can be reduced by silvicultural treatments which (a) maintain or restore diverse stand structure, and (b) control pine stand density at levels below which tree killing is economically important. The first of these approaches probably will have increasingly limited application in the future because economic factors seem to favor the continuing trend toward even-aged management of second-growth stands. Thus, thinning of dense stands will generally be the forest manager's first line of defense against the mountain pine beetle problem in ponderosa pine.

## SUMMARY

Outbreak tree killing of second-growth ponderosa pine by mountain pine beetle is an increasing problem in Oregon and Washington. Beetle impact is greatest on poor sites, where outbreaks result in natural thinnings from above and cause serious understocking. In contrast, on good sites, beetle-caused tree mortality constitutes thinning from below and generally seems to aid stand development, even though occasionally a few of the largest trees are killed. Severity of tree killing is strongly related to stand density on all sites, an indication that thinning of dense stands has promise as a silvicultural approach to preventing beetle outbreaks. During 1967, a pilot test of thinning was installed on 200 acres near Baker, Oregon. Four different spacing levels are expected to prevent severe tree killing for periods ranging from about 10 to 30 years.

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